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5 October 1965

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Enclosed are three copies each of the following proposals:

1. Sine Wave Test Targets with a Range of 1 - 1000 l/mm
2. Sine Wave Tester for Film Viewers.

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Enclosures: 3 copies each of two proposals

Sine Wave Tester for Film Viewers

The previously proposed sine wave tester, although perfectly suited for most tests, has one disadvantage when one wants to test film viewers. This is due to the fact that the earlier proposed method is based on a variable contrast target which has to be inserted in the film plane. Although this variable target can be minimized in size, it will never be as thin as a single sheet of film. This was understood during the discussions of this method and it was agreed that it would be necessary to partially dismantle film holders during tests. During the period of testing the principles and design of the proposed test equipment, it occurred to us that it is possible to modify the principle on which the test is made to such an extent that in the film plane only a target film is needed, while the rest of the equipment is on the image side. Such an instrument would be capable of testing all viewing equipment without the partial dismantling of the equipment. (The only exception is equipment where the image is presented at infinity to the eye, i. e., direct image viewers, where different equipment is needed to look at the image. The same restrictions hold also for the earlier proposed equipment.)

In general an instrument adapted to make measurements on specific equipment is bound to lose its versatility and such is the case in our proposed instrument. For instance, in our earlier version one could measure lens-film transfer function and lens-eye transfer function. This is not possible in our present version. It can, however, be used to test lenses on a test bench.

In the following pages we will describe the new solution and give a price proposal to build such an instrument.

Description of Instrumentation

A schematic diagram of the proposed set-up is shown in Fig. 1.

In the film holder (1) a target film is inserted during the test. This target is imaged in the image plane of the viewer (2). This image is viewed by the observer through a microscope. In this microscope an image of plane (2) is formed in plane (3); the image of (2) by the objective of the microscope. Image (3) is viewed through an eyepiece by the observer. This microscope we will call the image microscope.

Another microscope is used to look at a comparison target (4). Its objective is a zoom objective forming an image of (4) in plane (5). Plane (5) is viewed with an eyepiece by the observer. This microscope will be called the comparison microscope.

In our instrument the two microscopes are combined in such a way as to have only one combined eyepiece to view the two images (3) and (5) simultaneously. Furthermore, a phase shift plate is inserted in the path of the comparison

DESCRIPTION OF INSTRUMENTATION

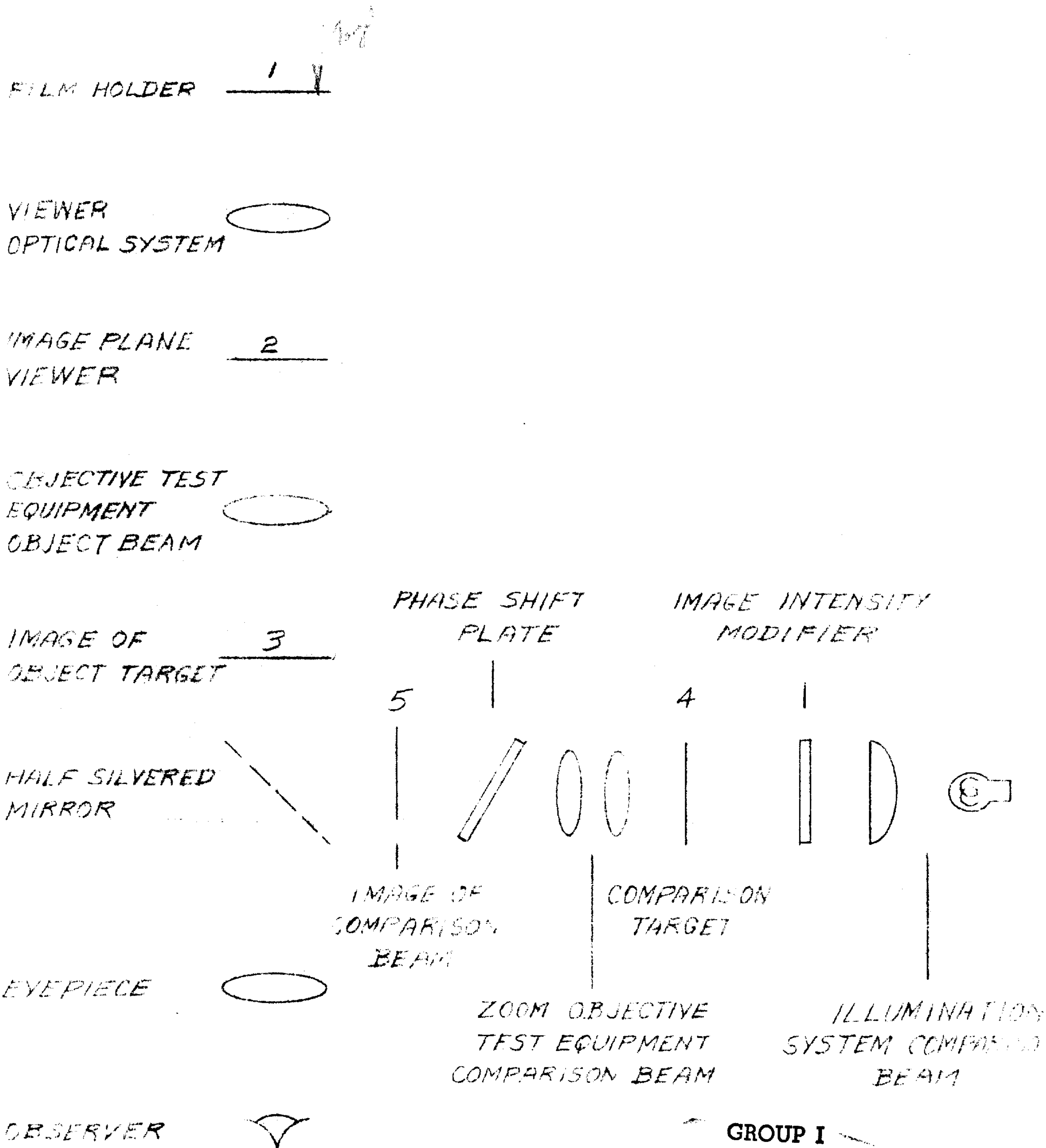

FIGURE 1

microscope which allows the observer to change the relative position between the two images (3) and (5). The comparison target is illuminated by an illumination system, the intensity of which can be controlled.

We will use a notation where I^i_{max} means the maximum intensity in the object- or image-plane numbered i in Fig. 1 and similarly I^i_{min} is the minimum intensity in the plane numbered i. We can then define a visibility

$$V^i = \frac{I^i_{max} - I^i_{min}}{I^i_{max} - I^i_{min}} \qquad (1)$$

Furthermore

τ = optical transfer coefficient of equipment under test

τ_1 = optical transfer coefficient for the objective of the image microscope

τ_2 = optical transfer coefficient for the objective of the comparison microscope.

We now have the following relationships

$$V^2 = \tau V^1$$

$$V^3 = \tau_1 V^2 = \tau \tau_1 V^1 \qquad (2)$$

and

$$V^5 = \tau_2 V^4 \qquad (3)$$

We now superimpose image (3) on image (5) and put them 180° out of phase and adjust the image intensity modifier so as to produce a combined image of uniform intensity. We will have to choose the right target combination so that with a minimum of use of the zoom system the frequencies in image (3) and (5) are equal. The right selection of targets in the two beams is governed by the condition that we want the two microscope objectives to be equal in power and the zoom magnification as close as possible to equal one. This is done so we can heep the following relation

$$\tau_1 = \tau_2 \qquad (4)$$

We will for the present ignore the possible presence of higher harmonics in images (3) and (5).

When the microscopes are adjusted in this way we have the relation

$$I^3_{max} + I^5_{min} = I^3_{min} + I^5_{max} \qquad (5)$$

Now introducing the factor α defined by

$$\alpha \left[I^3_{max} + I^3_{min} \right] = I^5_{max} + I^5_{min} \qquad (6)$$

We can now rewrite Equation(5)

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$$\frac{I^3_{max} - I^3_{min}}{\alpha\left[I^3_{max} + I^3_{min}\right]} = \frac{I^5_{max} - I^5_{min}}{I^5_{max} + I^5_{min}}$$

or with Equation (1)

$$V^3 = \alpha V^5$$

and introducing Equations (2), (3), and (4)

$$\tau \tau_1 V^1 = \alpha \tau_2 V^4$$

or

$$\tau = \alpha \frac{V^4}{V^1} \qquad (7)$$

The target contrast V^1 equals one for a high contrast target and therefore

$$\tau = \alpha V^4 \qquad (8)$$

We now can measure τ by the following three methods:

1. Adjust α (image intensity modifier) while V^4 is constant (say equal to one).
2. Adjust V^4 while α is a known constant.
3. Adjust both α and V^4.

We propose to use method 1 since for all methods means of measuring α have to be incorporated and, therefore, this is the simplest method.

When we start with a visibility $V^4 = 1$ our relation become extremely simple

$$\tau = \alpha \qquad (9)$$

The measurement of α is easily done by measuring the total amount of light in image (4) of the target and comparing this with the total amount of light in image (5) of the comparison target used.

When higher harmonics are present in the images (3) and (5) it will be impossible to adjust to a uniform intensity field of view; however, there will be a doubling of the image frequency when the proper adjustments are made and, therefore, the frequency doubling will be the criterion.

On the following page is the estimated cost breakdown for this system.

Estimated delivery time for this unit is five months.

Approved For Release 2002/06/17 : CIA-RDP78B04747A000700050020-8

Sine Wave Test Targets with a Range of 1-1000 l/mm

In order to make the sine wave tester as versatile as possible it is advantageous to have as many frequencies as possible available, and if possible available in one target.

Our preliminary experiments (the results of which are already sent to your representatives) indicate that we will be capable of making targets that have a frequency range of 1 l/mm to 1000 l/mm.

Since our contract [redacted] only calls for targets of a smaller frequency range, and the high frequency targets were to be supplied by the contracting agency, we propose to extend our present contract to include supplying single targets encompassing the full frequency range. Each target will have three target groups:

Group 1:	1 l/mm up to and including 10 l/mm
Group 2:	10 l/mm up to and lincluding 100 l/mm
Group 3:	100 l/mm up to and including 1000 l/mm

Two consecutive targets will have a frequency ratio of $\sqrt[10]{10}$ or 1.26.

Each target will have a definite position with respect to the next lower one, so as to enable the measurement of the phase of the transfer function of the equipment under test. (The precision with which the phase can be measured is still under study in our present contract.)

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